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Does Age Diversity Boost Technological Innovation? Exploring the Moderating Role of HR Practices

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Abstract

We shed new light on the linkages between age diversity and technological innovation, and explore the moderating effect of human resource practices on such relationships. Based on a linked dataset that contains cross-sectional survey data and longitudinal employer–employee data from Luxembourg, we show that the effect of age diversity on innovation depends on the age distribution pattern of employees: positive for firms characterized by heterogeneous age groups (variety), negative for those dominated by polarized age groups (polarization). HR practices such as information sharing mitigate the adverse effects of age polarization on innovation. Practices enhancing development such as training are found to play a significant and negative role in moderating the relationship between age diversity and innovation. We illustrate how academics and practitioners may use HR practices within the context of a heterogeneous aging workforce and the age-related differences in values and abilities between generations.

Introduction

Industrialized countries are witnessing higher life expectancies while at the same time fertility is declining and is likely to remain below the reproduction rate in the future. As a result, there has been a compositional shift from younger to older age groups within firms, and an increase in age diversity among the workforce. Recent studies have highlighted the multifaceted reality of age diversity, which has important competitive and ethical implications (McMahon, 2010) and implies a "new organizational paradigm" (Gilbert et al., 1999). Technological innovation is a social and multidimensional processes that involve the participation and interactions of individuals from different generations, which could challenge intergenerational knowledge

transfers and intergenerational cohesion. Accordingly, managing age diversity to support such an innovation has become increasingly critical.

There has been a notable increase in the efforts to develop theoretical and empirical frameworks to help in understanding the relationship between age diversity and company performance (labor productivity, innovation, etc.), however, producing mixed results (Van Knippenberg and Schippers, 2007). On the one hand, age diversity seems to favor idea and knowledge exchanges and to lead to enhanced performance (Grund and Westergaard-Nielsen, 2008). On the other hand, workplace diversity creates a number of problems in terms of communication, cooperation, and cohesion between employees, which might ultimately affect performance negatively. Such mixed results might be explained by the fact that prior studies consider age diversity as a single dimension, although Harrison and Klein (2007) established that it is multidimensional, comprising two aspects: variety and polarization. Age variety implies a group with heterogeneous ages, in which knowledge differences become manifest. This can encourage favorable synergies that increase labor productivity. Age polarization entails the separation of the workforce into distinct, homogeneous subgroups, which can trigger negative diversity outcomes and reduce labor productivity. Surprisingly, we can find no empirical studies on the relationship between these different dimensions of age diversity and technological innovation.

Moreover, some authors attribute the mixed results "to researchers' neglect of possible mediators and moderators in the relationship between age diversity and outcomes in the studies on organizational demography" (Kunze et al., 2011, p. 265). Hence, there is a need for more empirical attention to be paid to the ways in which diversity affects performance and on the contingency factors of such processes (Van Knippenberg and Schippers, 2007), such as human resources (HR) practices. Studying HR practices seems logical in this regard for several reasons: first, literature on "diversity management" has been expanding recently, and

"managing" often relies on the use of HR practices. Second, in the contemporary context of demographic change and rapid innovation, age – as well as the role of human development – is high on the agenda of human resource managers. Third, organizations have to meet new challenges concerning their HR management. Potential employees are not only more and more diverse with regard to sociodemographic characteristics (such as age), but also in terms of their needs and expectations (which are often linked with age). To accompany demographic changes due to the aging population, organizations need to develop strategies for the workforce in a more age-differentiated way to satisfy the changing needs and motives during people's lives (e.g., Adams and Shultz, 2007), and in turn to stay innovative and competitive. Fourth, literature on strategic HR management often refers to HR systems such as motivation-enhancing and incentive-related practices (Böckerman et al., 2012; White and Bryson, 2013). These frameworks provide a better understanding of the relationship between HR practices and employees' attitudes, as each HR bundle is aimed at different goals in specific contexts (Bal and De Lange, 2015). This approach advances the debate on the effects of HR practices according to age. Fifth, the specific effects HR practices may have on the age diversity–innovation linkages have, however, not been previously studied. Existing research has failed to integrate these concepts in a clear model, and offers little explanation of how the concepts may be linked exactly. Further, no previous empirical study has taken this issue into account. The current paper thus contributes to the body of literature that focuses on how companies deal with diversity through HR practices (see Bogaert and Vloeberghs, 2005; Süß and Kleiner, 2008).

In view of the above statements and knowledge gaps, the objective in this paper is twofold. First, we provide new insights into the relationship between age diversity and technological innovation. For this purpose, we adopt a multidimensional approach to conceptualize age

diversity, by using the two dimensions of age polarization and age variety,[1] and exploring their respective relationships with technological innovation. Second, we investigate the mechanisms through which HR practices lead to enhanced innovation linkages with age diversity, by considering HR practices as a possible moderator of the link between age diversity and technological innovation.

The current paper thus integrates two very different streams of research, one that deals with workplace diversity and the other with HR practices. We use cross-sectional data from the Luxembourg employer survey over the period 2010–2012 (one wave) and Luxembourg's longitudinal linked employer-employee data, available annually from 2009 to 2011 (three waves). Combining these two databases creates a sample of 1,422 Luxembourg firms, among which we find that distinct HR practices could have different moderating impacts.

1. Theoretical Background

Research on workforce diversity has identified different types of diversity: age, gender, ethnicity (or surface-level diversity), organizational tenure, functional, educational background, and personality (or deep-level diversity), among others. Harrison and Klein (2007, p. 1200) define diversity in a work setting as the "distribution of differences among the members of a unit with respect to a common attribute, X, such as tenure, ethnicity, conscientiousness, task attitude, or pay." While the definition of workforce diversity covers any form of objective or subjective dimension among workplace members, it is likely that not all these diversity types play an identical role with regard to innovation (Weiss et al., 2018). In this paper, we focus on age diversity and shed new light on its inconclusive effects on

[1] We use the term "age diversity" broadly, to encompass both age variety and age polarization.

innovation and explore the moderating effects of human resource practices on the relationship between age and innovation performance.

1.1.Age-related changes in expectations and motives

Age may explain changes in employees' work attitudes by affecting their needs, their expectations regarding future prospects, and their values at a particular stage in life. First, rooted in the life span psychology and socioemotional selectivity theories (Kanfer and Ackerman, 2004; Kooij et al., 2011), younger and older workers may differ in terms of emotional reactions. Older adults are more likely to maximize positive emotional experiences than negative ones (Carstensen and Mikels, 2005; Mather and Carstensen, 2005). Further, while young adults have more intense emotional reactions to negative stimuli and adversity at work, older people are better able to understand and control their emotions (Bruine de Bruin et al., 2014; Chapman and Hayslip, 2006). Second, research on decision-making and social relationships across the life span has shown age-related changes in needs and work values (Kanfer and Ackerman, 2004; Ng and Feldman, 2010). While older workers are more oriented toward fulfilling social needs, younger individuals display greater motivation to meeting their growth and career development needs (Ebner et al., 2006; Jans, 1989). Third, research into cognitive abilities and decision-making across the life span suggests that workers of different ages have distinct experiences, skills, and perceptions of technology and new trends (Vaportzis et al., 2017).

1.2. Age Diversity and Innovation

Different theoretical lenses have been used to analyze the relationship between innovation and age diversity. On the one hand, the general argument for the benefits of age diversity relies on the information/decision-making perspective (Grund and Westergaard-Nielsen, 2008; De Meulenaere et al., 2016) or the so-called value-in-diversity hypothesis (Cox and Blake, 1991). These theories predict that diverse age groups provide superior solutions to organizational

problems and can increase organizational efficiency, effectiveness, and profitability. That is, by creating, transferring, and absorbing various capabilities, a more diverse intergenerational knowledge base enhances problem-solving routines and innovative activities. Age diversity may create complementary, age-specific knowledge pools that can lead to such synergies (Horwitz and Horwitz, 2007) as employees of different ages have distinct experience, understanding, and perceptions of technology and new trends. In particular, younger employees may tend to have stronger academic skills, but be socially inexperienced. Older employees are often less at ease with new technologies, even when they are open to using technology; they may experience age-related challenges such as cognitive decline or technology-related barriers (Vaportzis et al., 2017). These older cohorts are, however, likely to have more work experience, social skills, and comprehension of global situations. By mixing people of various ages – and thus varied capacities, perspectives, and mental models (Cannella et al., 2008) – a firm can increase the skill diversity of work teams, encourage knowledge transfers, and enable interactions that lead to new knowledge combinations. If the different perspectives and mental models embodied in diverse workforces improve their collective knowledge, problem-solving capacity, and new idea generation (Østergaard et al., 2011), they should also lead to greater technological innovation.

On the other hand, diversity can also have detrimental effects. According to the organizational demography view (Pfeffer, 1985), social similarity is required for close interactions and communication. Age diversity implies different values, which might lead to communication problems, personal conflicts, low cohesion, or job dissatisfaction (Carton and Cummings, 2012; Milliken and Martins, 1996). Therefore, age diversity could act as a barrier to the transfer of knowledge between individuals. Social categorization, social identity, and similarity-attraction theories (Byrne, 1971) put forward similar arguments, which lead to the prediction that age diversity could instigate ingroup-outgroup distinctions and negative social

processes that would disrupt employees' cohesion and organizational outcomes. Prior studies also highlight that employees of different ages might also not be willing to share their experience. The communication difficulties and value conflicts would thus diminish social integration overall, which could be negative for performance (Backes-Gellner and Veen, 2013).

Not surprisingly, empirical research has produced mixed results. One group shows both positive and negative effects of age diversity. Zajac and colleagues (1991) find evidence that diversity in the age of employees relates positively to technological innovation in internal corporate joint ventures. Backes-Gellner and Veen (2013) also show that increasing age diversity has a positive effect on company productivity if – and only if – the employees involved are engaged in creative (rather than routine) tasks. By contrast, Østergaard and colleagues (2011) and Garnero and colleagues (2014) find that age diversity is harmful for innovation, company productivity, and wages.[2]

A second group of studies finds no significant (or an inconclusive) linkage. Neither Van der Vegt and Janssen (2003), McGuirk and Jordan (2012), nor Faems and Subramanian (2013) uncover any direct link between age diversity and innovative behavior. Using Danish longitudinal employer–employee data, Parrotta and colleagues (2014) also find no significant link between diversity in age and innovation. In a review of 80 studies of the effects of diversity on performance, Williams and O'Reilly (1998, p. 403) conclude that "diversity appears to be a double-edged sword, increasing the opportunity for creativity as well as the likelihood that group members will be dissatisfied and fail to identify with the group."

These opposing arguments and results suggest the need to look more closely at age diversity as a "unit-level, compositional construct" (Harrison and Klein, 2007, p. 1200), comprising variety ("differences in kind or category, primarily of information, knowledge, or

[2] Some research focuses on specific types of surface-level diversity other than age, such as gender (which has been mainly studied in the context of top management teams, see for instance Ruiz-Rimenez et al., 2016).

experience among unit members"), polarization or separation ("differences in position or opinion among unit members"), and disparity ("differences in concentration of valued social assets or resources such as pay and status among unit members – vertical differences that, at their extreme, privilege a few over many"). Each element is unique, but whereas polarization and variety relate to horizontal differences (i.e., in perception, opinion, or abilities), disparity implies vertical differences (e.g., social status or pay). Here, we focus on "horizontal" differences – namely knowledge and values – between younger and older employees, hence on variety and polarization.

Age variety is the "heterogeneity of ages represented in an organization, reaching its maximum in a firm with an equal share of employees for each potential age group – that is, a rectangular age distribution" (De Meulenaere et al., 2016, p. 196). Age polarization implies a separation of the workforce into distinct homogeneous subgroups such that "there are large, homogeneous subgroups of equal size that strongly differ in average age" (De Meulenaere et al., 2016, p. 196). Both types of age diversity can have positive and negative impacts on organizational performance (Harrison and Klein, 2007; De Meulenaere et al., 2016). We suppose that age variety is positively associated with technological innovation, while age polarization could hamper such innovation. Indeed, on one hand, age variety may induce diverse values, ways of thinking, and competences, which should foster positive complementarities between employees. The absence of large subgroups of employees of a similar age may reduce the value-based tensions between subgroups. Such "value gap" (De Meulenaere et al., 2016) is supposed to hamper cooperation and innovation. On the other hand, the presence of large and homogeneous subgroups of different ages due to polarization may generate personal conflicts or communication problems among employees. The produced group dynamics are likely to hamper cooperation and spur discrimination and conflict

between groups of different ages (Kunze et al., 2011), which may lead to reduced innovation and performance (Carton and Cummings, 2012).

1.3. The Moderating Role of HR Practices

While there has been a notable increase in efforts to develop theoretical and empirical frameworks for understanding the relationship between age diversity and firm innovation, very little is known about the mechanisms through which HR practices may moderate such effects. Understanding how specific HR practices influence the link between technological innovation and age diversity is crucial, as the optimal effect of diversity is likely to depend on how workplace diversity is managed (Pull et al., 2012; Parrotta et al., 2014; Martín-Alcázar et al., 2012). Innovation is a social process, in which employees – as part of a firm's human capital resources – participate and interact with each other (Østergaard et al., 2011; Amabile, 1988). Human capital resources have a demographic dimension (such as age, gender, or ethnic origin) and a cognitive dimension (such as experience, vocational training, and openness). Hence, employees' demographic characteristics and the way a company manages the interactions of heterogeneous employees should influence that company's performance in terms of innovation (Homan et al., 2008). By introducing HR practices as possible moderators in the relationship between age diversity and innovation, we assume that the extent to which the effects of diversity (age variety versus age polarization) on a company's technological innovation will vary according to which HR practices are introduced by the management.

In this paper, we consider the impact of five HR practices separately: development, teamwork, information sharing, financial incentives, and work–life balance. Although few studies have investigated HR practices separately, some recent research argues that each practice is aimed at different goals in specific contexts, and it is unlikely that all HR practices play an identical role with regard to technological innovation (Jiang et al., 2012; Bos-Nehles et al., 2013; Bal and de Lange, 2015).

The five practices were chosen for several reasons: First, they represent the five categories of "modern" HR practices identified by Laursen and Foss (2014). Second, they illustrate Lepak and Snell's (2002) typology of commitment-based financial incentives and work-life balance, and productivity-based (development) and collaboration-based (teamwork and information sharing) human resource practices. Third, they also are representative of the widely-used Ability, Motivation, and Opportunity (AMO) model, although this has been criticized as the three aspects of AMO, which may interact with each other to influence outcomes (for example, see Reinholt et al., 2011). There are numerous debates related to the interactions between the different individual HR practices, and the many configurations found by researchers, which depend on the choice of underlying practices and subpractices. In light of this, we chose to concentrate on five specific HR practices that we consider as essential for enhancing or modifying the age–innovation performance relationship. Indeed, they are particularly suited to advance the debate on the technological innovation effects of HR practices in a context of age diversity, and to shed additional light on the differentiated relationships between specific HR practices and innovation (Laursen and Foss, 2014).

We adopt a cognitive approach with regard to innovation and assume it is an interactive process in which individuals learn, enhance their knowledge, constantly seek interactions, and combine their knowledge to perform (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995). Prior studies focusing on HR practices that enhance upskilling and employees' development and innovation emphasize that such practices support the acquisition, reconfiguration, and exploitation of new knowledge, which is crucial for knowledge management and innovative performance (Beugelsdijk, 2008; Zwick, 2015; Laursen and Salter, 2014). Taking into account the role of employees' age distribution, age diversity may promote such learning processes and knowledge acquisition (van der Vegt and Janssen, 2003), though generation and life span theories (Bal and De Lange, 2015) also predict different impacts of upskilling

practices, depending on the age distribution in the workplace. Because the knowledge bases of young and old people are too different, the combination of knowledge required for innovation cannot take place. As the knowledge bases are heterogeneous, the combination and exchange of knowledge required for technological innovation might not readily occur. Accordingly, we suppose that HR practices such as development or training might encourage efficient exchanges of knowledge across generations marked by age variety, but that firms facing age polarization might instead suffer from a larger gap between their employees' abilities.

Prior studies provide contradictory results with regard to incentive systems such as rewards, benefits, or promotions for innovation. While some research suggests that incentive systems induce higher levels of effort and productivity (e.g., Lazear, 2000; Shearer, 2004), others provide evidence of distortions associated with these practices, as they focus only on financial incentives without the consideration of the intrinsic motivation of employees (e.g., Bloom and Van Reenen, 2011; Kanama and Nishikawa; 2017). Amabile (1996) summarizes the results of this stream of research by stating that monetary incentive systems encourage the repetition of simple routine tasks, in which effort is the main driver of productivity, while discouraging the exploration of new tasks involving creativity and innovation. In the context of age diversity, one can predict that the dynamics of adult development provide insights into how motivation might work among employees of different age groups. Older employees might be more interested in flexible work policies, perhaps because they care for children or elderly parents or else need more time for regeneration (Kanfer and Ackerman, 2004; Zwick, 2015). However, they may be less driven by achievement motives (demonstration of mastery and excellence compared with others) or openness to experience. They are less threatened by a failure to be promoted, and occupational achievement plays a lesser role when compared with employees in the earliest years of their careers. Therefore, we expect that incentive

practices such as rewards, benefits, or promotions affect innovation differently, which depends on the employees' age distribution of a firm. In the context of age polarization, where distinct homogeneous subgroups of generations strongly differ in average age, HR practices may reinforce the intergenerational conflicts due to different interests and values of diverse age groups. Indeed, since innovation is an interactive process involving individuals of different ages with heterogeneous backgrounds and values, we expect that monetary incentives as HR practices will induce additional friction and competition among employees, which could hamper social cohesion and communication. This could, in turn, lead to the reduction of a company's innovative results.

Literature also looks at nonmonetary incentives. The motivational psychology theory (e.g., Heckhausen et al., 2010) predicts that motivators such as monetary incentives may be counterproductive, because they exclude the autonomous motivation that is essential for successful problem solving, learning, and creativity. Such research affirms that rewards matter, but calls for softer, less controlling rewards. To test for the moderating role of nonmonetary incentives, we also investigate soft rewards in the form of work–life balance practices.

HR practices geared toward interaction and communication among employees have also received attention from researchers. New knowledge generated by the combination of knowledge possessed by employees of different ages leads to creativity and the development of innovations. Firms have a diverse workforce benefit from a broader combination of ideas and perspectives from different generations that enable the development of innovative opportunities (Miller and Triana, 2009; Ruiz-Jiménez et al., 2016). Thus, we assume that HR practices such as teamwork and information sharing that enhance interactions, communications, and the exchange of knowledge among employees are likely to motivate employees of different ages to engage in efforts to achieve organizational objectives,

including technological innovation. These practices offer employees opportunities to demonstrate their ability and intrinsic motivation (Jiang et al., 2012). Thus, companies investing in information sharing and teamwork practices emphasize more coordination and move decision-making authority and responsibility from the top to lower levels in the organizational hierarchy. Such practices reduce hierarchical barriers and value-based differences that arise between employees of different ages, and in turn enable firms to achieve innovative results.

Age diversity can also relate negatively to communication frequency (Zenger and Lawrence, 1989). In this context, HR practices aimed to improve exchanges and communication among members may mitigate this challenge. Working together and sharing information on a regular basis also should reduce the cognitive dissonance among employees, allowing them to make better use of their combined knowledge. These new combinations in turn will support efficient and innovative problem solving, due to the complementarity of the different employees' competencies, technological perceptions, methods, and knowledge. We thus extrapolate that opportunity-enhancing HR practices that support communication and teamwork, particularly across cohorts of different ages, should mitigate the negative effect of polarization, in terms of limiting information transfers across employees of different ages, as predicted by the value in diversity hypothesis (Cox and Blake, 1991). Differences between older employees' skills and intelligence (which tend to be oriented toward communication and problem solving) and those of younger employees (which tend to feature fluid intelligence and technology skills) may be offset by opportunity-enhancing practices that allow them to exchange experiences and types of knowledge.

Figure 1 illustrates our theoretical framework for the moderating role of HR practices on the relationship between age diversity (variety/polarization) and technological innovation.

INSERT FIGURE 1 ABOUT HERE

2. Methods

2.1. Sample

For this study, we use a rich data set derived from combining two sources. The first, the Luxembourg Employer Survey (LES), was conducted in 2013 by the Luxembourg Institute of Socio-Economic Research (LISER). This cross-sectional data set refers to the period 2010–2012 and contains information about companies (sector of activity, groups, number of employees, sales, and geographic market), their HR practices, and their technological innovations. It accounts for nonresponse and survey design probabilities and ensures representativeness. Our second data set is the Luxembourg Longitudinal Linked Employer–Employee Data (LLEED), available from Luxembourg's annual General Inspection of the Social Security report, for the years 2009–2011. This provides registry data for all employees in Luxembourg, including each worker's age, gender, and nationality. The LLEED also identifies each worker's employer, so we can match the information with the LES according to the firms' common identity numbers. We obtained a sample of 1,442 Luxembourg firms with at least 10 employees in the manufacturing and service sectors. The mean size is 78.9 employees, ranging from 10 to 3,995.

2.2.Measures

Appendix 1 provides the full definitions of variables.[3]

Technological Innovation. Similar to Mairesse and Robin (2011), we use a direct measurement, based on whether the firm introduced product or/and process innovations in the three-year period from early 2010 to late 2012. For our purposes, a product innovation is defined as the introduction of goods or services that are new to the market or the firm; a process innovation is defined as the introduction of new or significantly improved production or delivery methods, including substantially altered techniques, equipment, or software. Our

[3] Because of space limitation, the descriptive statistics and correlation matrix were not included, but are available upon request.

dependent variable, technological innovation, thus is a binary variable, equal to 1 if the firm implemented product or process innovations and 0 otherwise.

Age Variety. The employee's age is a natural number (17–67 years), so we could use different methods to measure age variety: standard deviation, average age of employees (Østergaard et al., 2011), variation coefficient of age (Backes-Gellner and Veen, 2013), average dissimilarity index (Harrison and Klein, 2007; Garnero et al., 2014), or Blau's index of heterogeneity (Ilmakunnas and Ilmakunnas, 2011; De Meulenaere et al., 2016). We chose the last, because Blau's index of heterogeneity simultaneously captures the number of categories represented within the workplace (richness) and the equivalence of the numbers for the individual categories (Parrotta et al., 2014). It is defined as:

$$Age\ Variety\ Index = 1 - \sum_{m=1}^{M} P_m^2,$$

where P_m^2 is the proportion of employees in age group m. We distinguish nine age groups (M = 9): younger than 25, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, and older than 59. The index takes a minimum value of 0 if all employees are equal (meaning perfect homogeneity) and a maximum value of (M – 1)/M if the proportions in all groups are equal (indicating perfect heterogeneity).

Harrison and Klein (2007) suggest using standard deviations to account for age polarization, because it is sensitive to the age range, and therefore reaches its highest value for firms in which age subgroups are the furthest apart. However, in line with De Meulenaere and colleagues (2016), who argue that this approach ignores the relative sizes of the subgroups, we adopt Esteban and Ray's (1994) polarization measurement. This is sensitive to both the size balance of the age subgroups and the distance between any two subgroups:

$$Age\ polarization\ index = k \sum_{i=1}^{N} \sum_{j \neq i}^{N} \pi_i^{1+\alpha}\, \pi_j |a_i - a_j|,$$

where π_i and π_j are the size balance of the subgroups i and j, and $|a_i - a_j|$ is the distance between these two subgroups. Representing sensitivity to polarization, with values between 0

and 1.6, a lower coefficient α implies greater weight assigned to the distance between subgroups, but less weight to the subgroup balance. For continuous attributes such as age, α should lie between .25 and 1 to satisfy the axioms of polarization (Duclos et al., 2004). Similar to De Meulenaere and colleagues (2016), we explicitly confirm that age polarization and age variety are two different notions by setting the level of α at values that make the correlation of age polarization with measurements of both age variety and age inequality (i.e., age polarization at $\alpha = 0$) lower than 0.5. In our case, the levels of α to guarantee this condition are 0.8 and 1.

HR Practices (see Appendix 1). We focus on five HR practices and variables. Development reflects the firm's upskilling activities in relation to training, internal mechanisms, and appraisal. It equals 1 if at least one of these three activities occurs and 0 otherwise (White and Bryson, 2013). Teamwork is equal to 1 when employees work on teams that autonomously decide how to identify and solve problems and 0 otherwise. Information sharing equals 1 when employees are informed about changes at work through frequent meetings with senior managers or can express their needs and expectations through an online platform, and 0 otherwise. The incentives variable is equal to 1 if the company offers its employees financial benefits such as bonuses, a company car, or life insurance, and 0 otherwise. Lastly, work–life balance is equal to 1 if the firm offers employees extra-legal benefits, such as a childcare center, financial assistance for childcare or elderly care, or flexible working hours, and 0 otherwise (White and Bryson, 2013).

Control variables. We include conventional control variables such as company size, activity sectors, the existence of an R&D department (binary), the number of competitors, and the proportion of graduates among the employees. We also include *gender* and *nationality diversity* (as an indicator of ethnic diversity), using Blau's index of heterogeneity. We control for organizational innovation, as existing literature has illustrated the close relationships

between the two types of innovation (e.g., Cozzarin, 2016). Hence, similar to Østergaard and colleagues (2011), we include each company's organizational policies: *Diversity Policy* in the form of internal mechanisms to promote diversity, *Collaboration* for technological innovation, *Quality Management* to satisfy customers and monitor production quality, and *Corporate Social Responsibility*. Lastly, we measure job security as the proportions of part-time and nonpermanent employees (De Meulenaere et al., 2016).

2.3.Estimation methods

As our dependent variable is binary, we use a probit model. Reverse causality can be a concern in workforce diversity studies (Garnero et al., 2014; Parrotta et al., 2014), because innovative processes (in terms of labor productivity, total factor production, and wages) might induce correlated changes in the company's workforce and their technological innovation efforts, which would not be due directly to changes in the workforce composition per se. However, without longitudinal data for technological innovation, we cannot address this issue. In a similar way to Garnero and colleagues (2016), and Böckerman and colleagues (2012), we use lagged levels of age polarization and age variety as internal instruments to endogenize these two factors; because changes in actual polarization and variety should correlate with their lagged levels, but the latter cannot correlate directly with our technological innovation-dependent variable. In this paper, the dependent variable and independent variables are computed from two independent databases. The technological innovation is computed from the cross-sectional survey data referring to the period 2010–2012 and the age polarization and variety are computed from the longitudinal administrative dataset of the period 2009–2011 (Appendix 1). Thus, the independent variables (polarization and variety) in 2009 and 2010 are prior to technological innovation of the period 2010–2012, they can be considered internal instruments for endogenizing polarization and variety in 2011.

As additional instruments, we include the lagged total number of people who quit and of new employees.

To test the potential interplay of age diversity and HR practices, we include interaction terms in the models. The estimates of the instrumenting equations (see Appendix 2) indicate that the F-statistic for the first-stage regressions of instrumenting equations exceeds 10; weak instruments are thus not a concern (Staiger and Stock, 1997). The over-identification tests indicate that the excluded instruments are not incorrectly omitted from the estimation of the technological innovation equation. The first-step estimation is shown in Appendix 3.

3. Results

The pairwise correlations between the main variables show that age polarization and age variety are significantly correlated, although with a low coefficient (-0.08[4]). Consistent with the motivation to control for different types of diversity, gender and nationality diversity measurements are included as controls. These two variables are significantly correlated with age variety, although the correlation coefficients are low. However, the variance inflation factors do not indicate any multicollinearity issue (mean VIF = 2.02; lowest tolerance value (1/VIF) = 0.18).

Table 1 contains the results of an instrumental probit model with measurements of age variety and age polarization, HR practices, and the control variables. Models 1 and 2 are the baseline versions, including only age variety and age polarization with the control variables. They reveal strong relationships between variety/polarization and innovation. Specifically, the relationship between age variety and innovation is positive and significant: a diverse age composition is positively associated with the likelihood of technological innovations being introduced. When age variety increases by one point, it enhances the likelihood of a

[4] With α (the sensitivity to polarization) being equal to 0 and 0.25, age polarization and age variety are highly correlated (0.75 and 0.62, respectively).

technological innovation by 1.84 points. The relationship of age polarization[5] with innovation is negative and significant: companies with distinct, homogeneous age groups are less likely to introduce technological innovations. A one-point increase in age polarization reduces the probability of technological innovation by 12.3 points.

In Model 3, we test for the main relationships (variety and polarization) jointly. The associations are still significant. With Models 4 and 5, we test for the impact of the five HR practices. The likelihood of innovating is positively associated with information sharing: the estimated link of information sharing is positive and strongly significant at the 1 percent level. The estimated link of development is also strongly significant and positive. However, we do not find any significant relationship between teamwork and innovation in any model. Also surprisingly, neither incentives nor work–life balance are associated with technological innovation. When we include age variety/polarization and the HR practices jointly, the results remain unchanged (Model 6), indicating that they are robust to the introduction of additional variables.

INSERT TABLE 1 ABOUT HERE

To explore the different mechanisms by which age variety and polarization are associated with innovation, we consider the five HR practices separately, while we also take into account employees' characteristics and company heterogeneity in sector and size. That is, we augment the baseline models (Table 1) with interaction terms of the measurements of age variety/polarization and the distinct HR practices (Table 2).

In Models 7 to 9 (Table 2), we analyze the interplay of diversity with development practices by the introduction of the interaction terms between them. Model 9, which includes both measurements of diversity jointly, indicates that age variety remains significant, but that the link of age polarization with innovation disappears. The interaction between development

[5] As the results with α being equal to 0.8 and 1 do not substantially differ, the subsequent empirical tests are based on the value 0.8. Results with α equal to 1 are available on request.

and age variety is highly significant and negative. These results show that development – such as training, annual appraisals, and internal skill development mechanisms – negatively moderates the relationships between age variety and innovation.[6] We find no significant interaction between development and age polarization.

With regard to HR practices linked to communication and knowledge exchange, the estimation results for *Teamwork* in Table 2 (Models 10 to 12) reveal that the interaction term between teamwork and age variety is negative and significant. Although workplaces with employees of different, homogeneous age groups are likely to be more innovative, HR practices that require teamwork mitigate this positive association between age variety and innovation.[7] The interaction term between polarization and teamwork is also not significant.

Models 13 to 15 test the interplay of information sharing with diversity. In Model 15, in which we include age variety, age polarization, and the interaction terms, the interaction between age variety and information sharing is not significant. Information sharing as an opportunity-enhancing practice does not positively moderate the relationship between age variety and innovation. However, we find a positive and significant interaction of age polarization and information sharing; that is, the negative impact of age polarization on technological innovation is weaker in organizations that rely on information sharing.

INSERT TABLES 2 and 3 ABOUT HERE

In relation to monetary incentives and work–life balance in Models 16 to 21 (Table 3), we find that the interaction terms with both incentives and work-life balance are not significant. When HR practices focus on motivating employees, such as pay-for-performance and work–life balance, they are not efficient in terms of improving the firm's capability to innovate in a

[6] We ran several models to test other indicators of development, such as bundles of development measures that regroup training, annual appraisals, and internal mechanisms and take values from 0 to 3, or else separated indicators such as only training, only annual appraisal, or only internal mechanisms. The results, available on request, match those in Table 2, and thus support the robustness of our results.

[7] We similarly ran multiple models to test other indicators of teamwork, including a bundle of teamwork measures that regrouped autonomous teamwork, quality circles, and job rotation and took values from 0 to 3 as well as separated indicators of each element. The results, available on request, again match those in Table 2 and reaffirm the robustness of our results.

working environment dominated by age variety and polarization. When we test for the links of all HR practices jointly (Model 22), the interaction terms between age variety and development and between age polarization and information sharing remain unchanged, whereas the moderating effect of age variety and teamwork disappears.

To investigate the interactions in more detail, simple regression lines that represent the significant interaction terms between HR practices and age diversity of the Model 22 were plotted separately to better understand the direction of their effects (Aiken and West, 1991). The introduction of interaction terms in the analysis accounted for a reliable amount of variance in technological innovation. To reduce potential collinearity between the interaction terms and the component variables, all component variable scales were centered (Aiken and West, 1991). Simple slopes analyses indicate that, as shown by the estimation results, for organizations implementing HR practices that enable communication and information sharing, there was a significant positive relationship between age polarization and technological innovation (Figure 1). In contrast, for organizations that implement development as a HR practice, there was a significant negative relationship between age polarization and technological innovation (Figure 2).

INSERT FIGURES 1 and 2 ABOUT HERE

To check whether the results remain valid when using a linear probability model, we ran OLS estimations for all the models with interaction terms between diversity and HR practices. The results are reported in Appendix 4. Overall, we find no differences between the results in Tables 2 and 3 and those in Appendix 4, with the exception of the one related to the interaction term between development and age variety that is no longer significant.

Among the control variables, we find a positive relationship between gender diversity and technological innovation, which is in line with previous empirical studies (e.g., Østergaard et al., 2011), but no evidence was found for nationality diversity. Organizational innovation is

positively associated with a greater likelihood to innovate. The effects of diversity policies are positive and significant. A firm's openness to diversity increases its innovation. However, the intensity of competition, expressed as the number of competitors, is not associated with technological innovation. Large firms and those having R&D department are likely to be more innovative. The results in Table 1 reveal a negative link between the proportion of part-time and of nonpermanent contracts and the likelihood to innovate (De Meulenaere et al., 2016), though the proportion of highly educated employees does not have a significant impact (Østergaard et al., 2011).

As robustness checks, we investigated whether the estimation results might differ according to the measurements of age variety and polarization. We estimated the models with two alternative indicators of age variety: the standard deviation of employees' ages (Østergaard et al., 2011) and the variation coefficient of age, defined as the ratio between the standard deviation and the mean of the ages (Backes-Gellner and Veen, 2013). The models reveal some differences, though we still find a positive and significant interaction term between age polarization and information sharing, and a negative, significant interaction term between age variety and teamwork. The interaction between age variety and development is no longer significant. When we use the variation coefficient of age, some results again change; specifically, the interaction of teamwork with age variety is no longer significant. We also estimated an alternative specification, using a different method to calculate age diversity. Both age variety and age polarization are bounded, continuous variables, so for technical purposes, related to the interaction terms with the dummy variables, we rescaled them as binary variables that equal 1 if the specific index (variety and polarization) is greater than the mean of that index and 0 otherwise. These binary indicators thereby reflect high versus low levels of variety/polarization. When we computed average effects of the interaction terms between binary variety/polarization and binary HR practices, the pattern of results matched

those in Tables 2 and 3. Therefore, the methods we used to calculate variety/polarization do not drive the results.

Further Analyses

The results presented in the previous sections suggest that technological innovation is related to age diversity and that this relationship is moderated by HR practices. However, as product innovation and process innovation could be driven by different determinants (Gómez et al., 2016; Cozzarin, 2016), the question arises of the extent to which they are differently associated with age diversity and HR practices. To address this, we separated product and process innovation into two dependent variables and ran linear models using the same set of explanatory variables and interaction terms. Tables 4 and 5 report the estimation results for product and process innovation, respectively.

INSERT TABLES 4 and 5 ABOUT HERE

The results suggest that age diversity is significantly associated with product innovation, while there is no evidence for process innovation. Hence, we find that a rise in the age variety of the workforce has a positive association with product innovation, while age polarization decreases the likelihood of an organization to introduce product innovation. These results are similar to those reported for technological innovation. Turning to the moderating role of HR practices, we still find that an organization with a workforce characterized by age variety that relies on a development strategy is less likely to introduce product innovation (Table 4). The interaction term between age polarization and information sharing is significant and positive, suggesting that the negative effect of workforce age polarization on the probability to introduce product innovation might be moderated by implementing communication-related HR practices such as information sharing. As a new result compared with the one obtained for technological innovation (Table 3), the interaction term between age polarization and teamwork is now significantly and negatively associated with product innovation (Table 4).

With regard to process innovation (Table 5), we find no evidence of a moderating role of development or information sharing. By contrast, teamwork as a HR practice appears to be a moderator of the link between process innovation and age variety.

4. Discussion and Conclusion

To the best of our knowledge, this article provides the first analysis of the effectiveness of HR practices in relation to the relationships between company technological innovation and age polarization and age variety, an important yet neglected issue that surrounds HR practices in academic and political discourses. Using an integrated data set from the cross-sectional LES for the period 2010–2012 (one wave) and the LLEED data available annually from 2009 to 2011 (three waves), we are able to take into account the prominent endogeneity issues associated with workforce diversity. Our findings contribute to three strands of literature: age diversity, innovation, and HR management.

First, with regard to age diversity, our results not only show that it matters for innovation, but that the direct relationships between age diversity and technological innovation vary according to the pattern of employees' age distribution. The linkages are positive for firms characterized by heterogeneous age groups (variety), but negative for those dominated by polarized age groups (polarization). In settings marked by age variety, the more diverse age spectrum facilitates knowledge transfers across generations and produces complementarities among the different forms of human capital possessed by younger and older workers (Cox and Blake, 1991; Grund and Westergaard-Nielsen, 2008). As people are repositories of unique knowledge, workforce age diversity provides the heterogeneity, flows, and re-combinations of knowledge that encourage innovative performance (Mohammadi et al., 2017). By contrast, age polarization implies differences in values and knowledge, impedes social cohesion, increases communication difficulties and value conflicts, and makes it

difficult to transfer company-specific knowledge across generations. We also acknowledge that the career advancement options for younger employees may appear limited, which could demotivate them from committing fully to the company's activities (Gibbons and Waldman, 2006). This is in line with theoretical arguments that suggest social similarity is important for interaction, communication, cohesion, and knowledge transfer (Byrne, 1971; Pfeffer, 1985).

Second, such results are also key for innovation literature; indeed, showing the differentiated impacts of age variety and age polarization reflect the contrasting theories on the benefits and disadvantages of age diversity. On the one hand, for age variety they provide support for the value-in-diversity hypothesis (Cox and Blake, 1991). Mixing people of various ages leads to diverse capacities, perspectives, and mental models (Cannella et al., 2008), which increases the skill diversity of work teams, encourages knowledge transfers, and favors interactions and collective problem-solving capacity, together with the generation of new ideas (Østergaard et al., 2011). Having a workforce composed of employees of different ages thus leads to greater technological innovation. However, if the age of employees is too polarized, with many young employees and many old ones, then all these benefits disappear, with age polarization having negative effects on innovation. This result provides support for the organizational demography view (Pfeffer, 1985), in which social similarity and similar values and mental models are required for close interactions and communication, for knowledge flows to circulate among team members. Age polarization thus acts as a barrier to the transfer of knowledge between individuals, in line with social categorization, social identity, and similarity–attraction theories (Byrne, 1971). Hence, this distinction between variety and polarization, which has not previously been made, is key to understand the underlying processes that lead, or not, to innovation.

Third, we also shed new light on the interplay between five main HR practices and age diversity, thereby it contributes to HR literature. On one hand, working from the knowledge-

based perspective (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995), we assumed that HR practices aiming at training employees would reinforce the positive association of age diversity with innovation. Instead, the practices erase and even contradict the supposed positive effects (the interaction term is negative). This is a counterintuitive result, which might have arisen because we use a *Development* variable that refers to a generic HR practice, suited to all employees regardless of their age. An emerging strand of literature instead recommends the implementation of development programs that are specific to older employees (e.g., Behaghel et al., 2014; Zwick, 2015) to help improve their productivity and commitment (Göbel and Zwick, 2013). Older employees appear reluctant to engage in generic training programs or ones that impose heavy demands on their fluid intellectual abilities (Kanfer and Ackerman, 2004). Instead, they should be more open to relevant, informal, age-specific training that they can tackle using their crystallized intelligence, such as conflict management (Zwick, 2015). Firms marked by a high level of age variety might prefer generic development practices, to encourage participation by younger employees and achieve an upskilled workforce. However, as an unintended consequence, they might be reinforcing the age bias associated with new technologies, affecting group identity and intergenerational cohesion (Behaghel et al., 2014), and limiting innovation performance. We find no evidence of a significant moderating role of development on innovation in relation to age polarization. This means that introducing generic upskilling practices is not sufficient to mitigate the adverse impact of age-related differences across polarized age groups.

On the other hand, the moderating role of HR practices varies according to the nature of the heterogeneous workforce. Looking at information sharing, we find that companies investing in HR strategies that enhance communication and knowledge exchange among employees are likely to be more innovative. Most interestingly, such practices also mitigate the adverse impact of age polarization on innovation. Thus, encouraging communication,

social cohesion, dialogue, and trust can mitigate the difficulties associated with age-related differences in knowledge, values, experience, and technological perceptions, leading to enhanced innovative activities (Laursen and Foss, 2003). However, with high levels of age variety, introducing teamwork practices actually reduces company innovation, perhaps because team-based systems in settings characterized by a large age variety create distress or encourage peer monitoring and the enforcement of group norms, rather than individual discretion and autonomy. An alternative explanation is that team-based systems mainly involve conflict resolution, which would limit the time and energy available for innovation. We find no significant interaction effect of teamwork and age polarization.

Some interesting managerial implications derive from our research. First, firms in the face of age polarization might counteract its negative impact on innovation by encouraging information sharing and communication among employees. This could be achieved for example through meetings between senior management and employees, in which employees would be able to express themselves and ask questions. Second, to embrace the benefits of variety, training and development practices should be adapted to each age category. Because younger and older people possess different skills and abilities, failing to suitably adapt development programs to their characteristics will hinder organizational performance and innovation. These results suggest that there is no single applicable theory of corporate age structures, and more research is needed on the moderating or even mediating roles of HR practices, particularly using longitudinal studies.

This study is not without limitations. First, we had access to longitudinal data for HR practices but not for technological innovation, which would have helped us to control for reverse causality. Producing databases to take into account this methodological aspect could constitute a first step for further research on the subject. Second, the current research considers generic HR practices regardless of employees' age. Companies characterized by age

diversity might benefit from more investment in human capital through age-specific HR practices to cope with the potentially declining abilities of senior employees. Considerable room for further research remains in this field. Moreover, apart from HR practices, future research should look at the varying boundary conditions under which age diversity might be differently related to innovation, such as organizational culture dimensions, leadership styles, types of tasks, and other motivation mechanisms.

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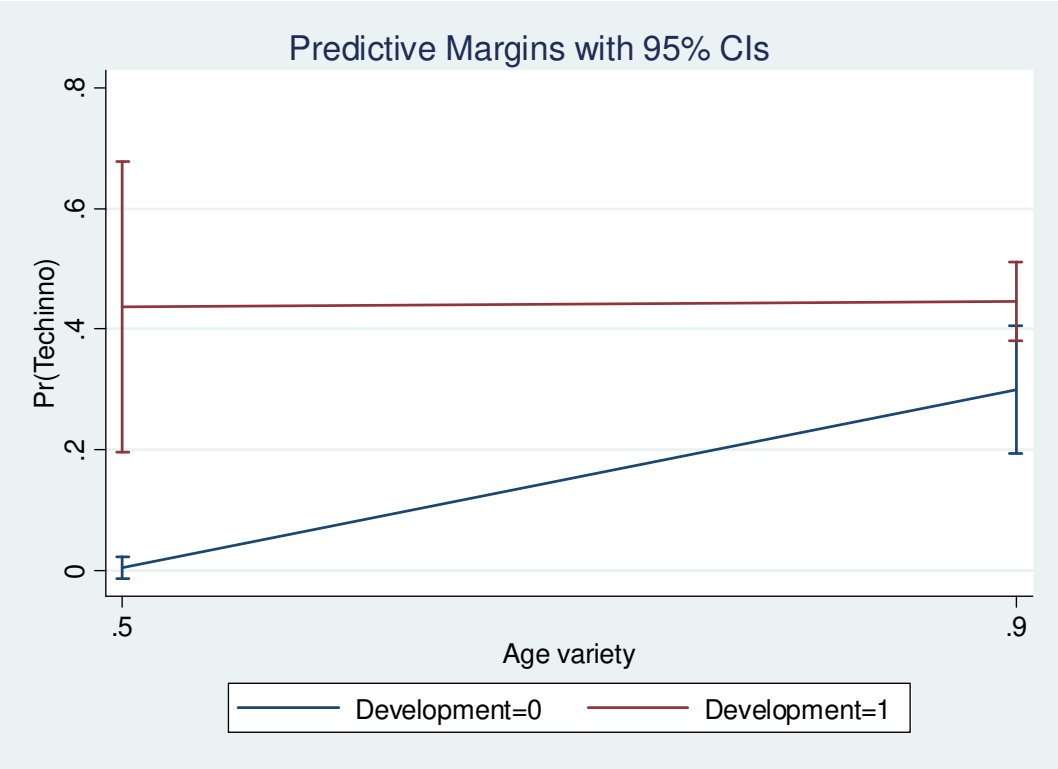

Figure 1: Slope regression of technological innovation on age variety at high and low development.

The *x*-axis reports the empirical scale limits of age variety (i.e., 0.5 and 0.9). High and low development are 1 *SD* above and 1 *SD* below the mean, respectively.

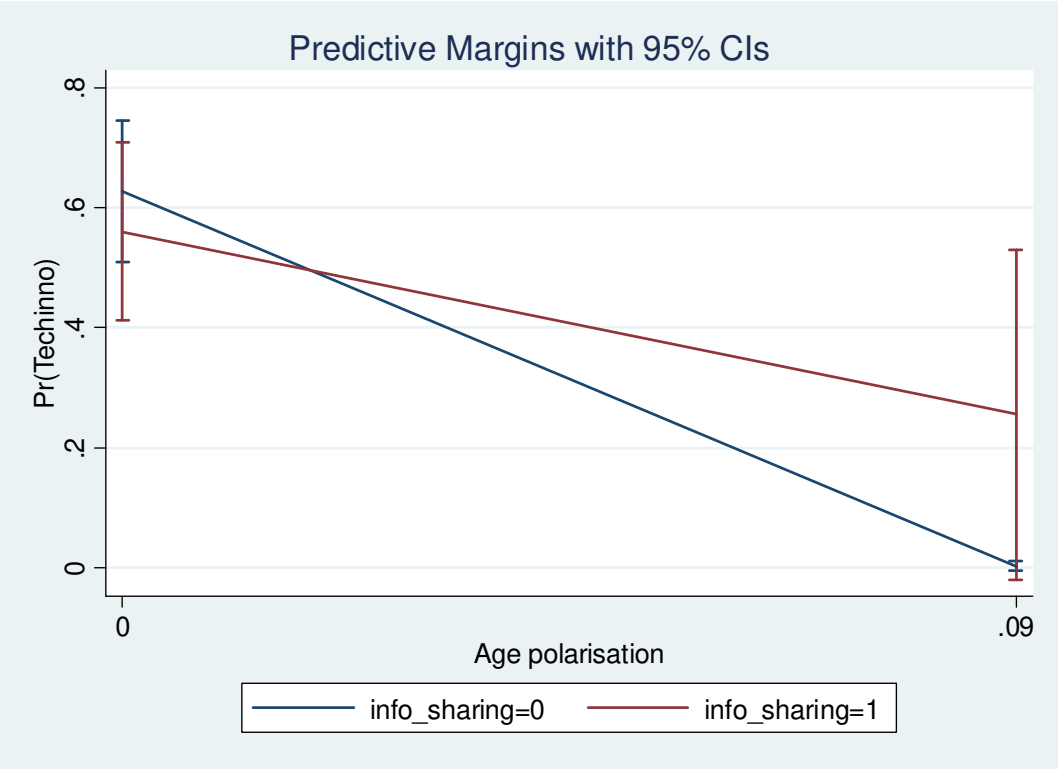

Figure 2: Slope regression of technological innovation on age polarization at high and low information sharing.

The *x*-axis reports the empirical scale limits of age polarization (i.e., 0.5 and 0.9). High and low information sharing are 1 *SD* above and 1 *SD* below the mean, respectively.

Table 1: Instrumental probit estimators of the effects of age variety and polarization on technological innovation

Variables	Without HR practices			With HR practices		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Age polarization	-12.32**		-10.60**	-11.80**		-10.94**
	(5.65)		(5.65)	(5.71)		(5.65)
Age variety		1.84*	1.77*		2.05**	2.00**
		(1.03)	(1.02)		(1.03)	(1.02)
Development				0.18***	0.20***	0.19***
				(0.07)	(0.07)	(0.06)
Teamwork				-0.03	-0.04	-0.03
				(0.06)	(0.06)	(0.06)
Information sharing				0.16***	0.15***	0.17***
				(0.06)	(0.06)	(0.06)
Pay performance				0.14	0.16	0.14
				(0.09)	(0.09)	(0.09)
Work-life				0.04	0.04	0.04
				(0.06)	(0.06)	(0.06)
Mean age	-0.02**	-0.0**	-0.02***	-0.02**	-0.03**	-0.02**
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)
Gender diversity	0.53**	0.50**	0.53	0.51**	0.48*	0.50**
	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)
Nationality diversity	0.22	0.17	0.17	0.24*	0.19	0.18
	(0.14)	(0.15)	(0.14)	(0.15)	(0.15)	(0.15)
Organizational innovation	0.94***	0.95***	0.95***	0.92***	0.92***	0.91***
	(0.06)	(0.05)	(0.05)	(0.06)	(0.05)	(0.06)
Collaboration	0.21***	0.21***	0.21***	0.20***	0.20***	0.20***
	(0.07)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)
Quality management	0.27***	0.27***	0.26***	0.23***	0.23***	0.21***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Diversity policy	0.20***	0.24***	0.24***	0.18**	0.20***	0.20***
	(0.07)	(0.07)	(0.07)	(0.057	(0.07)	(0.07)
Corporate social responsibility	0.27***	0.27***	0.27***	0.25***	0.24***	0.24***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Company size	0.01***	0.00***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Proportion of part-time	-0.66**	-0.79***	-0.70**	-0.59*	-0.71**	-0.64**
	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)	(0.29)
Proportion of nonpermanent c.	-0.57*	-0.49	-0.58*	-0.53*	-0.46	-0.54*
	(0.33)	(0.32)	(0.33)	(0.33)	(0.33)	(0.33)
R&D department	0.31**	0.31***	0.30***	0.30***	0.31***	0.29***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Foreign owned	-0.25**	-0.21***	-0.23***	-0.29***	-0.25***	-0.27***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)
Number of competitors	-0.04	-0.05	-0.04	-0.03	-0.04	-0.04
	(0.04)	(0.04)	(0.03)	(0.04)	(0.04)	(0.04)
Proportion of graduate employees	-0.02	0.01	0.01	-0.04	-0.03	-0.03
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.05	-1.89**	-1.34	-0.42	-2.42***	-1.88*
	(0.44)	(0.82)	(0.89)	(0.44)	(0.82)	(0.87)
Observations	1442	1442	1442	1442	1442	1442
Wald chi2	652	599	512	621	425	526
Log likelihood	5260	5482	6254	6528	6589	5985

Notes: Bootstrapped standard errors are in parentheses.
* Significant at 10%, ** significant at 5%, and *** significant at 1%.

Table 2: Instrumental probit estimators of the effects of age variety and polarization on technological innovation and moderating effects of HR practices

VARIABLES	Diversity×Development			Diversity×Teamwork			Diversity×Infosharing		
	Model 7	**Model 8**	**Model 9**	**Model 10**	**Model 11**	**Model 12**	**Model 13**	**Model 14**	**Model 15**
Age polarization	-15,981*		-12,254	-9,421*		-6,544	-19,524***		-19,541***
	(7.521)		(5.021)	(6.325)		(7.521)	(6.664)		(8.172)
Age variety		7,840**	7,352**		1,521**	1,812**		2,764	2,006
		(3.124)	(3.163)		(1.152)	(1.150)		(1.872)	(1.885)
Development	0.066	0.524**	0.245**	0.192**	0.185**	0.198***	0.173**	0.205***	0.181**
	(0.232)	(0.252)	(0.235)	(0.073)	(0.074)	(0.074)	(0.065)	(0.073)	(0.074)
Teamwork	-0.005	-0.001	-0.006	-0.152	-0.185	-0.135	-0.085	-0.013	-0.014
	(0.037)	(0.037)	(0.037)	(0.814)	(0.109)	(0.124)	(0.036)	(0.036)	(0.036)
Information sharing	0.171***	0.174***	0.182***	0.158***	0.165**	0.135***	-0.350*	1.132	-0.320
	(0.061)	(0.061)	(0.062)	(0.062)	(0.061)	(0.012)	(0.204)	(1.405)	(1.210)
Incentives	0.145	0.051	0.195	0.200	0.178	0.172	0.137	0.157	0.136
	(0.099)	(0.100)	(0.100)	(0.099)	(0.097)	(0.098)	(0.100)	(0.099)	(0.100)
Work-life	0.054	0.050	0.038	0.041	0.043	0.045	0.035	0.042	0.032
	(0.063)	(0.064)	(0.064)	(0.059)	(0.066)	(0.067)	(0.064)	(0.064)	(0.064)
Variety*Development		-7.303**	-6.627**						
		(3.662)	(3.258)						
Polarization*Development	3.782		2.581						
	(7.010)		(7.210)						
Variety*Teamwork					-4.624**	-4.380**			
					(1.604)	(2.000)			
Polarization*Teamwork				1.485		-9.325			
				(2.250)		(3.484)			
Variety*Infosharing								-1.181	-0.316
								(1.902)	(2.021)
Polarization*Infosharing							19.845***		17.676**
							(7.406)		(7.024)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.429	-7.657***	-6.659**	-1.009	-2.485**	-2.969***	-0.066	-3.001**	-1.532
	(0.454)	(2.641)	(2.027)	(0.582)	(0.825)	(0.879)	(0.479)	(1.498)	(1.632)
Observations	1,442	1,442	1,442	1,442	1,442	1,442	1,442	1,442	1,442
Wald chi2	419	478	432	418	425	418	389	374	425
Log likelihood	16245	12452	13528	15016	14025	15246	13524	14658	12578

Notes: Bootstrapped standard errors are in parentheses.
* Significant at 10%, ** significant at 5%, and *** significant at 1%.

Table 3: Instrumental probit estimators of the effects of age variety and polarization on technological innovation and moderating effects of HR practices (2)

VARIABLES	Diversity×Incentives			Diversity×Work–life			All Interactions
	Model 16	**Model 17**	**Model 18**	**Model 19**	**Model 20**	**Model 21**	**Model 22**
Age polarization	-6.521*		-6,854*	-10.453*		-9.510*	-13.958*
	(3.521)		(3.457)	(5.521)		(4.544)	(10.184)
Age variety		5,625	5.654		4.562**	3.552*	9.522**
		(5.521)	(1.945)		(1.854)	(1.256)	(3.521)
Development	0.184***	0.175***	0.174***	0.152**	0.145***	0.184**	0.175**
	(0.074)	(0.074)	(0.073)	(0.072)	(0.073)	(0.073)	(0.125)
Teamwork	-0.002	-0.002	0.003	-0.004	-0.002	-0.004	-0.214
	(0.037)	(0.037)	(0.037)	(0.035)	(0.032)	(0.021)	(0.185)
Information sharing	0.145***	0.158**	0.154***	-0.121***	0.154**	0.145***	0.358**
	(0.061)	(0.062)	(0.061)	(0.061)	(0.061)	(0.061)	(0.495)
Incentives	-0.652	2.458	3.254	0.554	0.125*	0.142	2.625
	(0.241)	(0.523)	(0.658)	(0.099)	(0.100)	(0.099)	(4.542)
Work-life	0.052	0.045	0.044	0.008	0.154	1.452	0.874
	(0.064)	(0.063)	(0.064)	(0.214)	(1.325)	(1.512)	(0.254)
Variety*Development							-4.632**
							(2.857)
Polarization*Development							-4.965
							(6.632)
Variety*Teamwork							-4.689
							(4.784)
Polarization*Teamwork							0.325
							(0.685)
Variety*Infosharing							0.145
							(1.652)
Polarization*Infosharing							14.87**
							(6.854)
Variety*Incentives		-5.185	-4.541				-4.002
		(5.352)	(5.523)				(5.851)
Polarization*Incentives	14.524		14.850				8.845
	(0.251)		(0.524)				(5.623)
Variety*Work-life					-2.124	-2.148	-0.425

					(2.215)	(2.125)	(1.652)
Polarization*Work-life				1.088		-1.524	-2.252
				(8.896)		(5.254)	(8.112)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.450	-6.145	-4.522	0.210	-2.524**	-2.528*	-8.335
	(0.775)	(4.758)	(4.780)	(0.352)	(1.812)	(1.654)	(5.621)
Observations	1,442	1,442	1,442	1,442	1,442	1,442	1,442
Wald chi2	418	398	435	348	462	431	427
Log likelihood	15016	14524	16352	12544	13258	14562	12584

Notes: Bootstrapped standard errors are in parentheses.
* Significant at 10%, ** significant at 5%, and *** significant at 1%.

Table 4: OLS estimation results for product innovation

	Diversity×Development	**Diversity×Teamwork**	**Diversity×Information sharing**	**Diversity×Work-life**	**Diversity×Incentives**	**All interactions**
Age variation	0.443	0.735**	0.203	0.377	0.385	0.082*
	(0.588)	(0.367)	(0.452)	(0.454)	(0.887)	(0.714)
Age polarisation	-2.114	-2.331*	-4.024*	-1.397	-0.023	-0.240*
	(2.228)	(2.089)	(2.100)	(2.188)	(3.871)	(3.146)
Development	0.182	0.058**	0.054**	0.056**	0.057**	0.191**
	(0.582)	(0.028)	(0.028)	(0.028)	(0.028)	(0.482)
Teamwork	0.006	1.561**	0.006	0.006	0.006	1.670***
	(0.015)	(0.795)	(0.015)	(0.015)	(0.015)	(0.612)
Information sharing	0.041*	0.039*	-0.238	0.040**	0.040*	0.411**
	(0.024)	(0.024)	(0.484)	(0.024)	(0.024)	(0.369)
Incentives	0.039	0.040	0.040	0.040	-0.566	-0.535
	(0.035)	(0.035)	(0.035)	(0.035)	(0.790)	(0.615)
Work-life	-0.003	-0.003	-0.004	0.088	-0.004	0.131
	(0.025)	(0.025)	(0.025)	(0.495)	(0.025)	(0.387)
Variety*Development	-0.484*					-0.634*
	(2.353)					(2.021)
Polarization*Development	-0.136					-0.138

	(0.685)					(0.567)
Variety*Teamwork		-2.701				-2.987
		(1.876)				(1.537)
Polarization*Teamwork		-1.572*				-1.678***
		(0.811)				(0.624)
Variety*Infosharing			3.293			4.290**
			(2.474)			(2.006)
Polarization*Infosharing			0.229**			0.400**
			(0.574)			(0.434)
Variety*Work-life				-0.039		-0.081
				(0.580)		(0.454)
Polarization*Work-life				-2.223		-2.664
				(2.958)		(2.320)
Variety*Incentives					0.821	0.799
					(0.933)	(0.726)
Polarization*Incentives					-2.740	-3.032
					(4.095)	(3.219)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,442	1,442	1,442	1,442	1,442	2,562
R-squared	0.247	0.249	0.248	0.248	0.248	0.252

Standard errors in parentheses
*** p<0.01, ** p<0.05, and * p<0.1

Table 5: OLS estimation results for process innovation

	Diversity×Development	Diversity×Teamwork	Diversity×Information sharing	Diversity×Work-life	Diversity×Incentives	All interactions
Age variation	0.452	0.091	-0.034	0.238	-0.067	0.063
	(0.513)	(0.320)	(0.395)	(0.396)	(0.774)	(0.625)
Age polarization	-0.319	1.224	-0.702	1.153	-1.382	-0.347
	(1.944)	(1.824)	(1.834)	(1.909)	(3.379)	(2.754)
Development	0.485*	0.038	0.036*	0.037	0.036	0.509*
	(0.508)	(0.024)	(0.024)	(0.024)	(0.024)	(0.422)
Teamwork	0.013	0.151**	0.012**	0.012	0.013	0.165**
	(0.013)	(0.694)	(0.013)	(0.013)	(0.013)	(0.535)
Information sharing	-0.005	-0.005	-0.167	-0.006	-0.005	-0.370
	(0.021)	(0.021)	(0.423)	(0.021)	(0.021)	(0.323)
Incentives	-0.020	-0.017	-0.018	-0.017	-0.179	-0.437
	(0.031)	(0.031)	(0.031)	(0.031)	(0.689)	(0.538)
Work-life	0.019	0.020	0.020	0.347	0.020	0.328
	(0.022)	(0.022)	(0.022)	(0.432)	(0.022)	(0.339)
Variety*Development	-0.485					1.295
	(2.053)					(1.770)
Polarization*Development	-0.522					-0.612
	(0.598)					(0.496)
Variety*Teamwork		-2.605*				-2.629*
		(1.637)				(1.346)
Polarization*Teamwork		-0.099				-0.111
		(0.708)				(0.546)
Variety*Infosharing			0.083			1.052
			(2.160)			(1.756)
Polarization*Infosharing			0.192			0.401
			(0.502)			(0.380)
Variety*Work-life				-0.271		-0.287

				(0.506)		(0.397)
Polarization*Work-life				-3.864		-2.840
				(2.580)		(2.032)
Variety*Incentives					0.162	0.455
					(0.815)	(0.636)
Polarization*Incentives					0.929	1.432
					(3.576)	(2.818)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,442	1,442	1,442	1,442	1,442	2,562
R-squared	0.194	0.196	0.194	0.195	0.194	0.194

Note : Standard errors in parentheses

*** p<0.01, ** p<0.05, and *p<0.1

Appendix 1: Variable Definitions

Variable	Definition
Innovation	Equal to 1 if the firm introduced new or significantly improved products or processes during the three years from early 2010 to late 2012 and 0 otherwise
Diversity	
Age polarization	Esteban and Ray index in 2011
Age variety	Blau index in 2011
Instruments	
Age polarization in t-1	Esteban and Ray index in 2010
Age polarization in t-2	Esteban and Ray index in 2009
Age variety in t-1	Blau index in 2010
Age variety in t-2	Blau index in 2009
Number of quits in t-1	Total number of employees who quit in 2010
Number of new hires in t-1	Total number of new employees in 2010
Control variables	
Teamwork	Equal to 1 if at least one of the following statements is true: (a) at least 25% of employees (not senior executives) currently work in a team where the members jointly decide how work is done; (b) at least 25% of employees are involved in groups that meet voluntarily and regularly to identify and solve work-related problems; or (c) at least 25% of employees are able to perform the tasks of their colleagues during their absences and 0 otherwise
Information sharing	Equal to 1 if at least one of the following statements is true: (a) high frequency of meetings between senior management and all employees (meetings); (b) high duration of the meetings used by employees to express themselves and ask questions (changes with employees involved), or (c) senior management seeking to stimulate employees' participation by internet surveys (attitude surveys) and 0 otherwise
Development	Equal to 1 if at least one of the following statements is true: (a) at least 25% of employees have received training days taken on working time; (b) at least 25% of employees have benefited from an annual appraisal; or (c) the firm offers an internal mechanism to encourage employees to develop their skills and careers and 0 otherwise
Incentives	Equal to 1 if the firm offers employees (not senior executives) at least one of the following benefits: (a) premiums or bonuses linked to individual performance; (b) company car or car fee participation; (c) supplementary pension or life insurance; or (d) meal vouchers and 0 otherwise
Work-life	Equal to 1 if the firm offers employees (not senior executives) at least one of the following extra-legal benefits: (a) slot in a childcare center; (b) financial assistance for childcare; (c) financial assistance to take care of the elderly or disabled; (d) days off for family reasons above the legal minimum; or € working at home in normal working hours for most or some employees and 0 otherwise
Collaboration	Equal to 1 if the firm made use of external experts between early 2010 and late 2012 to stimulate new ideas or creativity among employees and 0 otherwise
Quality management	Equal to 1 if the firm introduced at least one of the following activities: (a) frequently monitor customer satisfaction though questionnaires, focus groups, and analysis of complaints; (b) monitor on a continuous basis the quality of its production processes or service delivery; or (c) regularly update databases that document good work practices or lessons learned and 0 otherwise
Diversity policy	Equal to 1 if the firm has internal mechanisms to promote diversity (gender, age, and nationality) and 0 otherwise
Corporate social responsibility	Equal to 1 if the firm is active at least in one of the three fields of corporate social responsibility: (a) economic (e.g., quality label); (b) environmental (e.g., waste reduction); or (c) social (e.g., diversity management) and 0 otherwise
Organizational innovation	Binary variable, equal to 1 if between early 2010 and late 2012, the firm make significant organizational changes such as business practices, methods of organizing work responsibilities and decision-making, and external relations) and 0 otherwise.

Gender diversity	Continuous variable. Equal to 1 minus the Herfindahl concentration index. It takes the minimum value 0 when all employees are equal, meaning a perfect homogeneity, and maximum value (M-1)/M when shares in all gender groups (M) are equal signifying perfect gender heterogeneity
Nationality diversity	Continuous variable. Equal to 1 minus the Herfindahl concentration index. It takes the minimum value 0 when all employees are equal, meaning a perfect homogeneity, and maximum value (M-1)/M when shares in all nationality groups (M) are equal signifying perfect nationality heterogeneity
Mean age	Firm's mean age
Firm size	Logarithm of the number of employees
Part-time	Proportion of part-time employees in the firm
Nonpermanent contracts	Proportion of nonpermanent contracts in the firm
External experts	Equal to 1 if the firm involves external experts in the innovation process and 0 otherwise
R&D department	Equal to 1 if there is an R&D department within the firm and 0 otherwise
Foreign owned	Equal to 1 if the firm is foreign owned and 0 otherwise
Number of concurrent	Equal to 1 if the firm has fewer than 5 competitors; 2 if the firm has between 6 and 25; and 3 if the firm has more than 25
Proportion of graduate employees	Score ranking from 1 to 4 to reflect the proportion of the employees with higher education degrees (Bac+4/+5, Master, Ph.D.). Equal to 1 if the proportion is less than 5%, 2 if between 6% and 24%, 3 if between 25% and 49%, and 4 if the proportion is greater than 50%.
Manufacturing	Manufacturing sector (reference)
Construction	Construction
Trade	Trade, accommodation, and food service
Accommodation	Low-tech manufacturing
Transportation	Transportation and storage
Communication	IT and communications
Finance	Finance
Other services	Other services

Appendix 2: Validity of the Exclusion Restriction (n = 1442)

	Age polarization	Age variety
First-stage F test	4.241	3.01
p-value	(0.038)	(0.092)
Over-identification test (Hansen, 1982)		
J statistic	0.751	
Chi-square	(0.701)	

Notes: These statistics are merely indicative, computed with 2SLS linear probability models, rather than the estimation strategy used to obtain the results in Table 1.

Appendix 3: Instrumenting Regressions of Endogenous Diversity

	Polarization	***Variety***
Age variety in t-1	0.007***	0.805***
	(0.002)	(0.017)
Age variety in t-2	0.001	0.001
	(0.001)	(0.009)
Age polarization in t-1	0.52***	-0.3214***
	(0.020)	(0.045)
Age polarization in t-2	0.119***	0.195***
	(0.021)	(0.092)
Number of quits in t-1	0.000***	0.000
	(0.001)	(0.001)
Number of new employees in t-1	-0.000**	0.000*
	(0.000)	(0.000)
Controls	Yes	Yes
Observations	1442	1442

Notes: Standard errors are in parentheses. * significant at 10%; ** significant at 5%; and *** significant at 1%

Appendix 4: OLS estimation results

	Diversity×Development	Diversity×Teamwork	Diversity×Information sharing	Diversity×Work-life	Diversity×Incentives	All interactions
Age polarization	-1.732	-1.635	-3.567**	-1.613*	-2.640	-2.250**
	(2.266)	(2.127)	(2.138)	(2.227)	(3.940)	(3.205)
Age variety	0.808**	0.696**	0.331	0.449	-0.128	0.176**
	(0.599)	(0.373)	(0.460)	(0.462)	(0.903)	(0.727)
Development	0.522	0.053*	0.050*	0.052*	0.052*	0.691*
	(0.592)	(0.028)	(0.028)	(0.028)	(0.028)	(0.491)
Teamwork	-0.003	1.058	-0.003	-0.003	-0.003	0.979
	(0.015)	(0.809)	(0.015)	(0.015)	(0.015)	(0.623)
Information sharing	0.048**	0.047**	-0.159	0.048**	0.048**	0.426**
	(0.024)	(0.024)	(0.493)	(0.024)	(0.024)	(0.376)
Incentives	0.033	0.035	0.035	0.035	-0.506	-0.637
	(0.036)	(0.036)	(0.036)	(0.036)	(0.804)	(0.626)
Work-life	0.013	0.013	0.013	0.067	0.013	0.064
	(0.025)	(0.025)	(0.025)	(0.504)	(0.025)	(0.394)
Variety*Development	-0.520*					-0.722
	(0.697)					(0.578)
Polarization*Development	-1.324					-1.363
	(2.394)					(2.059)
Variety*Teamwork		-1.042*				-0.963
		(0.826)				(0.635)
Polarization*Teamwork		-2.908				-2.736
		(1.910)				(1.566)
Variety*Infosharing			0.181			0.455
			(0.585)			(0.442)
Polarization*Infosharing			2.106**			3.515**
			(2.518)			(2.044)
Variety*Work-life				-0.001		-0.017
				(0.591)		(0.462)
Polarization*Work-life				-2.011		-1.647
				(3.010)		(2.364)
Variety*Incentives					0.644	0.802
					(0.950)	(0.740)
Polarization*Incentives					0.199	0.207
					(4.169)	(3.279)

Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,442	1,442	1,442	1,442	1,442	2,562
R-squared	0.242	0.247	0.249	0.247	0.246	0.259

Notes: Standard errors are in parentheses. * significant at 10%; ** significant at 5%; and *** significant at 1%